# ECOLOGICAL RISK ASSESSMENT AT IR PROGRAM SITE 16 (FORMER CREOSOTE DIP TANK AND FIRE FIGHTING TRAINING AREA)

## NAVAL CONSTRUCTION BATTALION CENTER NORTH KINGSTON, RHODE ISLAND

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# 1. ECOLOGICAL RISK ASSESSMENT

The purpose of the Ecological Risk Assessment (ERA) is to determine if, under expected exposure conditions, chemicals detected in soil, seep sediment, and seep water samples collected from Site 16 are at concentrations that may cause unacceptable risk to organisms using the area.

The key guidance followed in this ERA are the *Navy Policy for Conducting Ecological Risk Assessment* (U.S. Navy 1999) and *Ecological Risk Assessment Guidance for Superfund* (U.S. EPA 1997). These two approaches are very similar in that they are based on a tiered, step-wise protocol.

Tier 1 of the screening-level ERA consists of two components:

1. Problem formulation and ecological effects evaluation (Step 1); and
2. Exposure estimate and risk characterization (Step 2).

Navy policy adds a refinement, termed Tier 2, Step 3a, of the conservative exposure assumptions used in the Tier 1, Step 2 food web that leads to an exit criteria evaluation. The Navy procedure is shown in Figure 1.

## 1.1 PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION

Problem formulation represents the scoping stage of the ERA, and consists of the following elements:

- Environmental setting of the site;
- Identification of receptors of concern;
- Development of a Conceptual Site Model (CSM); and
- Assignment of assessment and measurement endpoints.

### 1.1.1 Environmental Setting of Site 16

Site 16 is located adjacent to Allen Harbor in the eastern portion of the Naval Construction Battalion Center (NCBC) Davisville (Figure 2). The Site was the location of a creosote dip tank area, where, during the 1960s, wood piles were dipped into tanks containing creosote and staged in the area to dry. In addition, a former fire fighting training area was reportedly located in the Site. In such an area, temporary structures were doused with flammable materials, ignited, and fire fighters then put these fires out. Such an operation could have released chemicals to the soil and ground water under Site 16. Currently the land is not used, and consists of the remnants of these former activities. Future land use plans include commercial development.

With the exception of tidal, fringing wetland adjacent to Allen Harbor, the Site contains upland habitat. A site visit was conducted on 7 October 1999 to identify potential

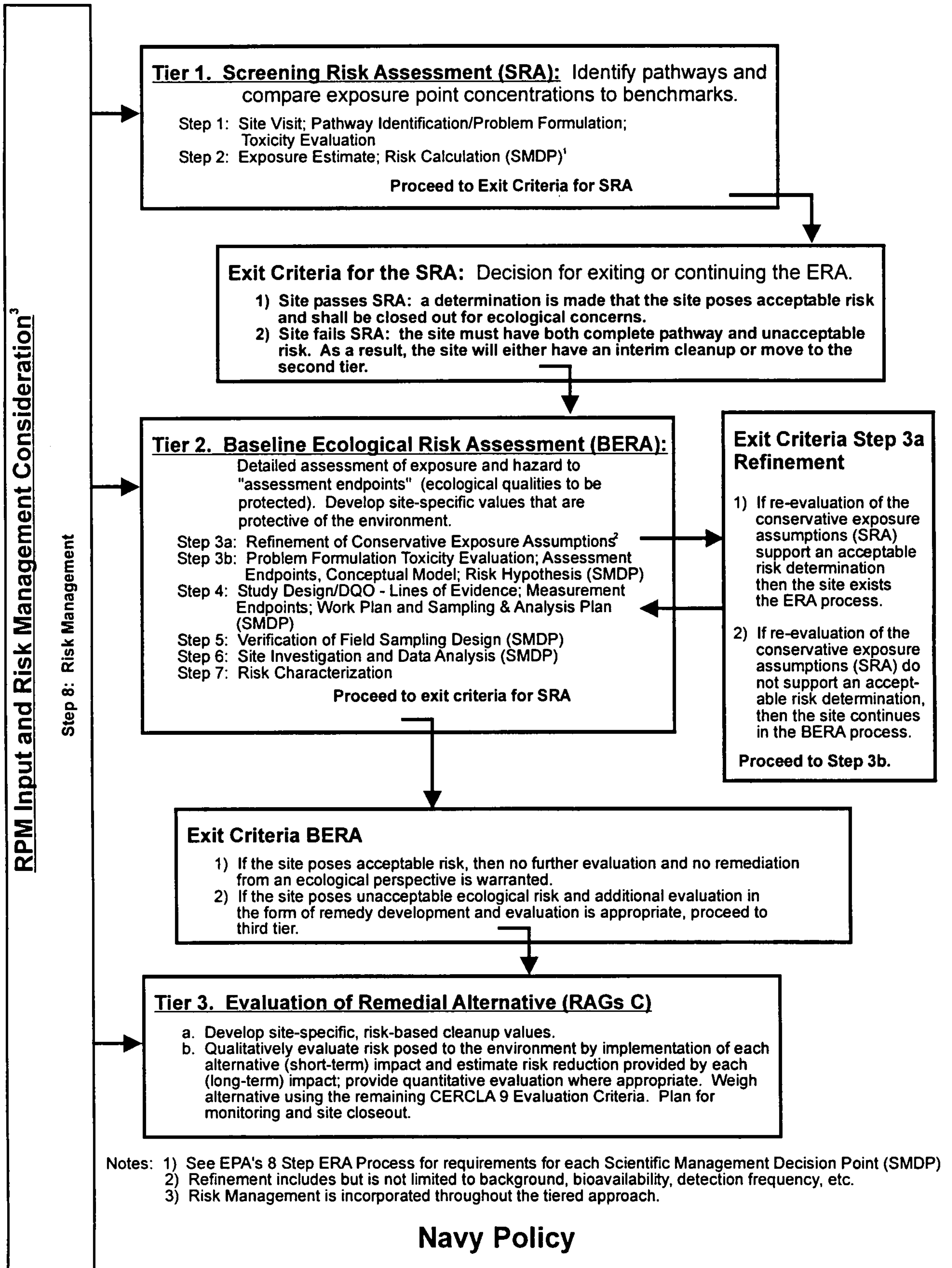


**Figure 1. Navy Ecological Risk Assessment Tiered Approach.**

Source: U.S. Navy, 05 April 1999.

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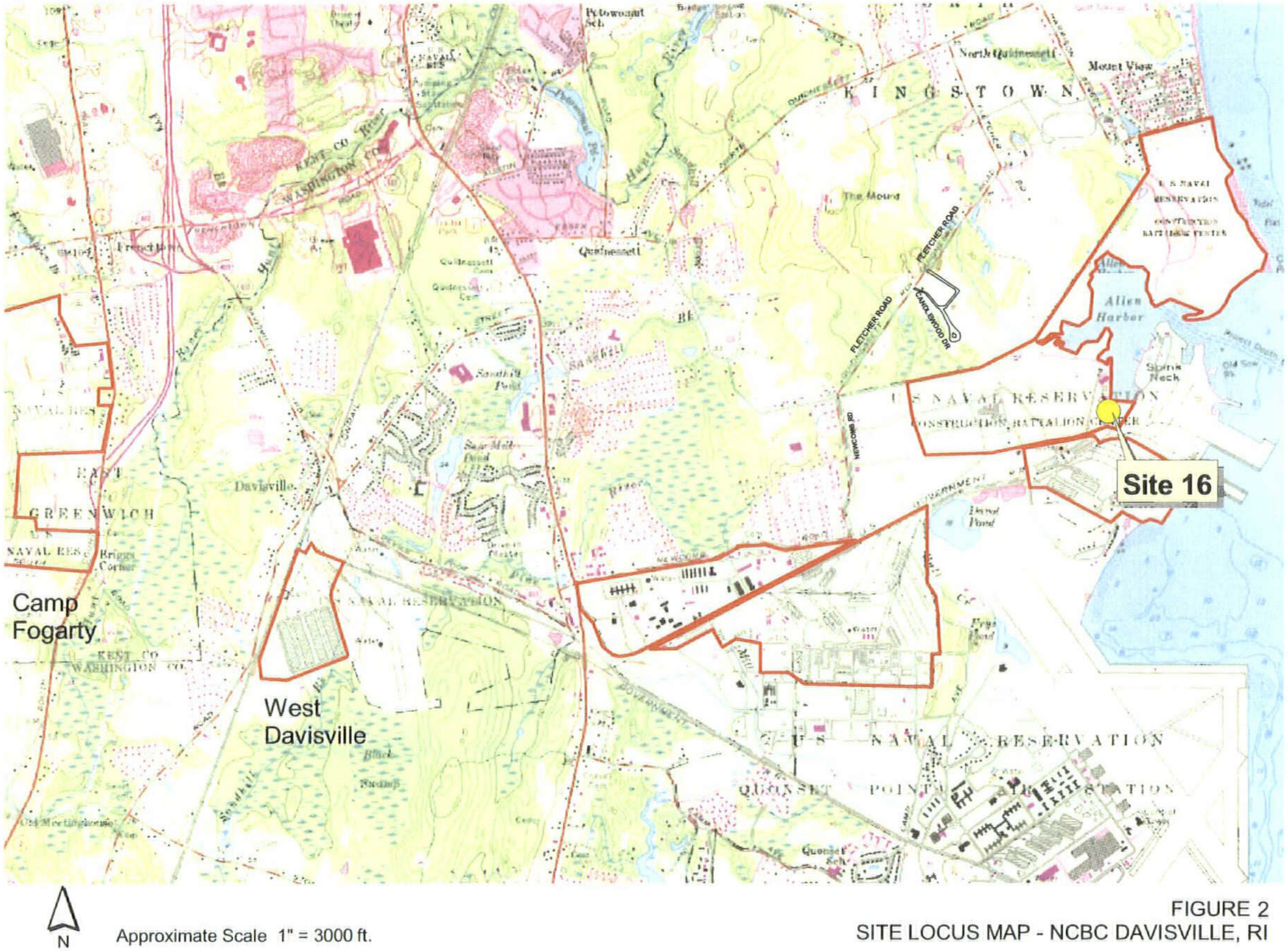


FIGURE 2
SITE LOCUS MAP - NCBC DAVISVILLE, RI

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complete exposure pathways that may exist on Site 16, and characterize the environmental setting with respect to habitat. The Site has a vegetative cover of bushes and small trees with localized areas of asphalt paving. The majority of the Site provided good habitat for several terrestrial plant, mammal, and bird species. Autumn olive (*Elaeagnus umbellata L.*), multiflora rose (*Rosa multiflora*), Northern bayberry (*Myrica pennsylvanica*), eastern red cedar (*Juniperus virginiana L.*), and Asiatic bittersweet (*Celastrus orbiculatus*) were common vegetative species. The areas of dense vegetation would provide good cover and food for white-tailed deer (*Odocoileus virginianus*) and Eastern cottontail (*Syvilagus floridanus*). Wildlife observations made while onsite included: Eastern cottontail, Northern mockingbird (*Mimus polyglottos*), Northern cardinal (*Cardinalis cardinalis*), house finch (*Carpodacus mexicanus*), mute swan (*Cygnus olor*), bank swallow (*Riparia riparia*), Canada goose (*Branta canadensis*), glaucous gull (*Larus hyperboreus*), and great black-backed gull (*Larus marinus*).

### 1.1.2 Identification of Receptors of Concern (ROCs)

Ecological Receptors of Concern (ROCs) are species or guilds of species that are important to the ecology of the study area and that may be susceptible to chemical constituents detected at the Site. Based on observations made during the site visit, and potential contaminant pathways identified and incorporated into the CSM (Section 1.1.3), the following ROCs and associated exposure pathways were identified:

- Marine invertebrates and fish—direct contact with seep water and/or seep sediment;
- Terrestrial plants and invertebrates—uptake and/or direct contact with surface soil;
- Omnivorous birds (American robin)—dietary ingestion of contaminated food items and incidental soil;
- Herbivorous mammals (Eastern cottontail)—dietary ingestion of contaminated food items and incidental soil;
- Carnivorous mammals (red fox)—dietary ingestion of contaminated food items and incidental soil.

### 1.1.3 Conceptual Site Model

The CSM for the Site 16 ERA is illustrated in Figure 3. The model incorporates key elements of problem formulation including contaminant sources, fate and transport, exposure pathways, and exposure mechanisms. For most receptors, the primary exposure is via surface soil, either by direct contact or via dietary routes. Potential risk to marine fish and plankton is evaluated by screening against seep water concentrations, i.e., a direct contact route. Similarly, potential risk to marine invertebrates, or benthos, is evaluated relative to chemical concentrations in sediment.

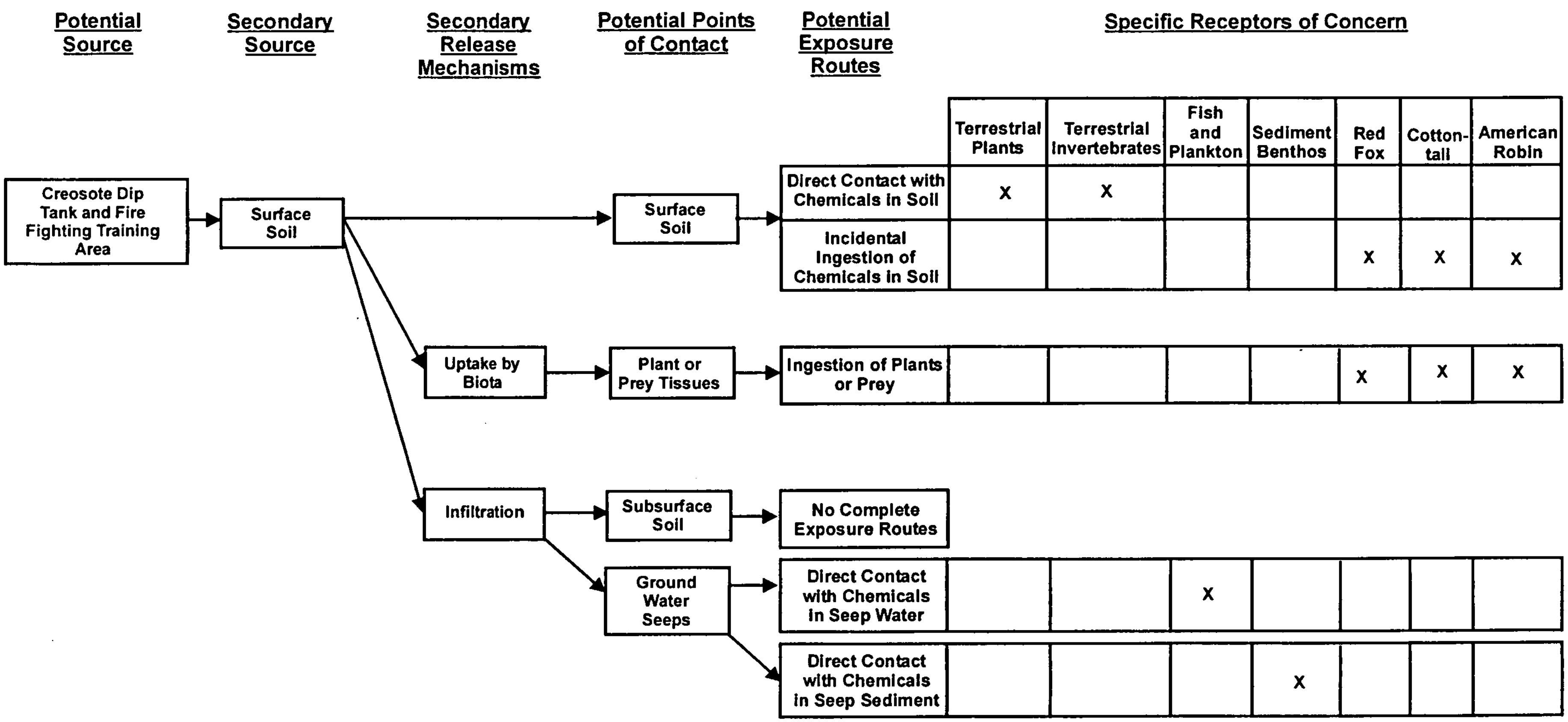


**Figure 3. Ecological Risk Conceptual Site Model for Site 16, Naval Construction Battalion Center.**

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### 1.1.4 Assessment and Measurement Endpoints

U.S. EPA (1997) guidance states that assessment endpoints—defined as "an explicit expression of the environmental value that is to be protected"—must be selected in an ecological risk assessment. Testable hypotheses and measurement endpoints are developed to evaluate threats to the assessment endpoints. Assessment endpoints and testable hypotheses were developed for the Site 16 ERA (Table 1). The assessment endpoints identified cover a broad range of trophic levels from terrestrial plants and invertebrates to marine fish and plankton to birds and mammals. Measurement endpoints involve screening of media concentrations for the lower trophic levels and food-web exposure assessment for the higher (bird and mammal) trophic levels.

## 1.2 ENVIRONMENTAL EXPOSURE ASSESSMENT AND RISK CHARACTERIZATION

Step 2 of the Tier 1 process consists of two components (U.S. Navy 1999; U.S. EPA 1997): (a) exposure assessment, and (b) risk characterization. In this ERA, exposure is based on the maximum concentration of a chemical detected in any medium. Risk characterization is based on calculation of the Hazard Quotient (HQ):

$$HQ = \text{maximum site concentration/screening benchmark}$$

If the site concentration is higher than the screening benchmark, the HQ is greater than 1.0, and potential risk is inferred. If the site concentration is lower than the screening benchmark, the HQ is less than 1.0, and no risk is inferred. As described in the next section, benchmarks are specific to the environmental medium, ROC, and pathway involved. For example, screening benchmarks for Site 16 seep water are National Ambient Water Quality Criteria (AWQC). In the case of food-web analysis, benchmarks are in the form of body-weight normalized doses referred to as Toxicity Reference Values (TRVs). To the fullest extent possible, all benchmarks are based on No Observed Adverse Effects Level (NOAEL) toxicological studies.

The initial step in exposure assessment and risk characterization is referred to as the Chemical of Potential Concern (COPC) screening.

### 1.2.1 COPC Screening Approach

In the Tier 1 process, the COPC screen serves two purposes. First, it serves as the risk calculation for lower trophic level terrestrial organisms (plants, invertebrates) and aquatic organisms. Second, the surface soil COPC screen not only identifies potential risk to plants and invertebrates, but the results are also used to identify chemicals that may pose risk to higher trophic level terrestrial organisms (mammals and birds). That is, any HQs exceeding 1.0 from the surface soil COPC screen are considered a potential threat to higher trophic organisms and are carried into the food-web analysis.

The screening benchmarks used in the COPC screening are listed in Table 2. This list has been updated from that provided in the RI Work Plan (EA 2000). Analytes not detected in an

## TABLE 1. ASSESSMENT ENDPOINTS FOR ECOLOGICAL RISK SCREENING AND FOOD WEB MODELING

| Assessment Endpoint | Null Hypothesis | Measurement Endpoint | Specifics of Assessment |
|---|---|---|---|
| Ecological health of terrestrial invertebrate and plant communities | Soils are not exhibiting a detrimental effect on invertebrate or plant survival and growth | • Evaluation of soil chemistry with respect to screening values | • Comparison of soil concentrations to screening values |
| Ecological health of marine fish and plankton communities | Seep water is not exhibiting a detrimental effect on survival, growth, or reproduction of fish and plankton | • Evaluation of seep water chemistry with respect to screening values | • Comparison of seep water concentrations to screening values |
| Ecological health of marine benthic organisms | Seep sediments are not exhibiting a detrimental effect on benthic organisms | • Evaluation of sediment chemistry with respect to NOAA screening values | • Comparison of sediment concentrations to NOAA ERLs or other appropriate benchmarks |
| Long term health and reproductive capacity of omnivorous avian species (American robin) | Ingestion of COPC in prey does not have a negative impact on growth , survival , and reproductive success of the species | • Evaluation of dose in prey based on surface soils data and dietary exposure models | • The risk associated with the calculated dose will be evaluated by comparison to Toxicity Reference Values (TRV) |
| Long term health and reproductive capacity of herbivorous mammalian species (Eastern cottontail) | Ingestion of COPC in food does not have a negative impact on growth , survival , and reproductive success of the species | • Evaluation of dose in prey based on surface soils data and dietary exposure models | • The risk associated with the calculated dose will be evaluated by comparison to TRVs |
| Long term health and reproductive capacity of primarily carnivorous mammalian species (red fox) | Ingestion of COPC in prey does not have a negative impact on growth , survival , and reproductive success of the species | • Evaluation of dose in prey based surface soil data and dietary exposure models | • The risk associated with the calculated dose will be evaluated by comparison to TRVs |

**TABLE 2. SOURCES OF SCREENING BENCHMARKS USED F R SITE 16, NCBC DAVISVILLE**

| Analyte | Matrix | Benchmark (ppm) | Source of Screening Criteria |
|---|---|---|---|
| *Inorganics* | | | |
| ALUMINUM | Surface Soil | NA[1] | U.S.EPA (2000) |
| ARSENIC | Surface Soil | 10 | Efroymson et al. (1997a) |
| BARIUM | Surface Soil | 500 | Efroymson et al. (1997a) |
| BERYLLIUM | Surface Soil | 10 | Efroymson et al. (1997a) |
| CADMIUM | Surface Soil | 1.6 | RIVM 1997 |
| CHROMIUM | Surface Soil | 10 | Efroymson et al. (1997b) |
| COBALT | Surface Soil | 20 | Efroymson et al. (1997a) |
| COPPER | Surface Soil | 40 | RIVM (1997) |
| LEAD | Surface Soil | 50 | Efroymson et al. (1997a) |
| MANGANESE | Surface Soil | 500 | Efroymson et al. (1997a) |
| MERCURY | Surface Soil | 2.2 | RIVM (1997) |
| NICKEL | Surface Soil | 90 | Efroymson et al. (1997b) |
| SELENIUM | Surface Soil | 1 | Efroymson et al. (1997a) |
| SILVER | Surface Soil | 50 | Efroymson et al. (1997b) |
| THALLIUM | Surface Soil | 1 | Efroymson et al. (1997a) |
| VANADIUM | Surface Soil | 20 | Efroymson et al. (1997b) |
| ZINC | Surface Soil | 50 | Efroymson et al. (1997a) |
| *PAH* | | | |
| ACENAPHTHENE | Surface Soil | 20 | Efroymson et al. (1997a) |
| ACENAPHTHYLENE | Surface Soil | 1 | Quebec MOE (1988) |
| ANTHRACENE | Surface Soil | 10 | Quebec MOE (1988) |
| BENZO(A)ANTHRACENE | Surface Soil | 1 | Quebec MOE (1988) |
| BENZO(A)PYRENE | Surface Soil | 1 | Quebec MOE (1988) |
| BENZO(B)FLUORANTHENE | Surface Soil | 1 | Quebec MOE (1988) |
| BENZO(G,H,I)PERYLENE | Surface Soil | 1 | Quebec MOE (1988) |
| BENZO(K)FLUORANTHENE | Surface Soil | 1 | Quebec MOE (1988) |
| CHRYSENE | Surface Soil | 1 | Quebec MOE (1988) |
| DIBENZ(A,H)ANTHRACENE | Surface Soil | 1 | Quebec MOE (1988) |
| FLUORANTHENE | Surface Soil | 1 | Netherlands (in: Beyer 1990) |
| FLUORENE | Surface Soil | 30 | Efroymson et al. (1997b) |
| INDENO(1,2,3-CD)PYRENE | Surface Soil | 1 | Quebec MOE (1988) |
| NAPHTHALENE | Surface Soil | 5 | Quebec MOE (1988) |
| PHENANTHRENE | Surface Soil | 5 | Quebec MOE (1988) |
| PYRENE | Surface Soil | 10 | Quebec MOE (1988) |
| *Pesticide/PCB* | | | |
| 4,4'-DDT | Surface Soil | 2 | RIVM (1995) |
| ALPHA-BHC | Surface Soil | 0.5 | Netherlands (in: Beyer 1990) |
| ALPHA-CHLORDANE | Surface Soil | 0.5 | Netherlands (in: Beyer 1990) |
| AROCLOR-1260 | Surface Soil | 40 | Efroymson et al. (1997a) applies to Total PCB |
| GAMMA-CHLORDANE | Surface Soil | 0.5 | Netherlands (in: Beyer 1990) |
| *Dioxin/Furan* | | | |
| All compounds | Surface Soil | No data | |
| *SVOC* | | | |
| 2-METHYLNAPHTHALENE | Surface Soil | 5 | Based on naphthalene as a surrogate |
| BIS(2-ETHYLHEXYL)PHTHALATE | Surface Soil | 30.05 | RIVM 1994, 2000 |
| CARBAZOLE | Surface Soil | No data | |
| DIBENZOFURAN | Surface Soil | No data | |
| DI-N-BUTYL PHTHALATE | Surface Soil | 200,000 | Efroymson et al. (1997a) |
| *VOC* | | | |
| 2-BUTANONE | Surface Soil | No data | |
| ACETONE | Surface Soil | No data | |
| METHYLENE CHLORIDE | Surface Soil | No data | |
| TOLUENE | Surface Soil | 200 | Efroymson et al. (1997a) |
| *Inorganics* | | | |
| BARIUM | Seep Water | 0.0038 | Suter (1996) |
| COBALT | Seep Water | 0.00306 | Suter (1996) |
| MANGANESE | Seep Water | 0.0803 | Suter (1996) |
| MERCURY | Seep Water | 0.00094 | EPA (1999c) marine chronic AWQC |
| NICKEL | Seep Water | 0.0082 | EPA (1999c) marine chronic AWQC |
| *PAH* | | | |
| ACENAPHTHENE | Seep Water | 710 | Buchman (1999) |
| ACENAPHTHYLENE | Seep Water | 0.03 | Buchman (1999) marine acute value/10 |
| ANTHRACENE | Seep Water | 0.03 | Buchman (1999) marine acute value/10 |
| FLUORANTHENE | Seep Water | 0.016 | Buchman (1999) |
| FLUORENE | Seep Water | 0.03 | Buchman (1999) marine acute value/10 |
| NAPHTHALENE | Seep Water | 235 | Buchman (1999) marine acute value/10 |
| PHENANTHRENE | Seep Water | 0.0046 | Buchman (1999) |
| PYRENE | Seep Water | 0.03 | Buchman (1999) marine acute value/10 |
| *Pesticide/PCB* | | | |
| ALPHA-BHC | Seep Water | 0.00244 | Suter (1996) |
| DIELDRIN | Seep Water | 0.0000019 | EPA (1999c) marine chronic AWQC |

## TABLE 2. SOURCES OF SCREENING BENCHMARKS USED FOR SITE 16, NCBC DAVISVILLE

| Analyte | Matrix | Benchmark (ppm) | Source of Screening Criteria |
|---|---|---|---|
| ENDRIN | Seep Water | 0.0000023 | EPA (1999c) marine chronic AWQC |
| HEPTACHLOR EPOXIDE | Seep Water | 0.0000036 | EPA (1999c) marine chronic AWQC |
| *SVOC* | | | |
| 2-METHYLNAPHTHALENE | Seep Water | 30 | Buchman (1999) marine acute value/10 |
| DIBENZOFURAN | Seep Water | 0.0204 | Suter (1996) |
| *VOC* | | | |
| 1,2-DICHLOROETHENE | Seep Water | 22.4 | Buchman (1999) marine acute value/10 |
| TRICHLOROETHENE | Seep Water | 0.2 | Buchman (1999) marine acute value/10 |
| VINYL CHLORIDE | Seep Water | 0.0878 | Suter (1996) |
| *Inorganics* | | | |
| ALUMINUM | Sediment | 18000 | Buchman (1999) |
| ANTIMONY | Sediment | 2 | Long and Morgan (1990) (ER/L) |
| ARSENIC | Sediment | 8.2 | Long et al. (1995) (ER/L) |
| BARIUM | Sediment | 20 | EPA (1977) |
| BERYLLIUM | Sediment | 10 | Based on soil value |
| CADMIUM | Sediment | 1.2 | Long et al. (1995) (ER/L) |
| CHROMIUM | Sediment | 81 | Long et al. (1995) (ER/L) |
| COBALT | Sediment | No data | |
| COPPER | Sediment | 34 | Long et al. (1995) (ER/L) |
| LEAD | Sediment | 46.7 | Long et al. (1995) (ER/L) |
| MANGANESE | Sediment | 260 | Buchman (1999) |
| MERCURY | Sediment | 0.15 | Long et al. (1995) (ER/L) |
| NICKEL | Sediment | 20.9 | Long et al. (1995) (ER/L) |
| SELENIUM | Sediment | 1 | New Jersey DEP (1987) |
| VANADIUM | Sediment | No data | |
| ZINC | Sediment | 150 | Long et al. (1995) (ER/L) |
| *PAH* | | | |
| ACENAPHTHENE | Sediment | 0.016 | Long et al. (1995) (ER/L) |
| ACENAPHTHYLENE | Sediment | 0.044 | Long et al. (1995) (ER/L) |
| BENZO(A)ANTHRACENE | Sediment | 0.261 | Long et al. (1995) (ER/L) |
| BENZO(A)PYRENE | Sediment | 0.43 | Long et al. (1995) (ER/L) |
| BENZO(B)FLUORANTHENE | Sediment | no data | |
| BENZO(G,H,I)PERYLENE | Sediment | 0.17 | Persaud et al. (1993) |
| BENZO(K)FLUORANTHENE | Sediment | 0.24 | Persaud et al. (1993) |
| CHRYSENE | Sediment | 0.384 | Long et al. (1995) (ER/L) |
| FLUORANTHENE | Sediment | 0.6 | Long et al. (1995) (ER/L) |
| FLUORENE | Sediment | 0.019 | Long et al. (1995) (ER/L) |
| INDENO(1,2,3-CD)PYRENE | Sediment | 0.2 | Persaud et al. (1993) |
| PHENANTHRENE | Sediment | 0.24 | Long et al. (1995) (ER/L) |
| PYRENE | Sediment | 0.665 | Long et al. (1995) (ER/L) |
| *Pesticide/PCB* | | | |
| 4,4'-DDD | Sediment | 0.002 | Long and Morgan (1990) (ER/L) |
| 4,4'-DDE | Sediment | 0.0022 | Long et al. (1995) (ER/L) |
| 4,4'-DDT | Sediment | 0.001 | Long and Morgan (1990) (ER/L) |
| AROCLOR 1260 | Sediment | 0.0227 | Long and Morgan (1990) (ER/L) |
| DELTA-BHC | Sediment | 0.003 | Persaud et al. (1993) |
| DIELDRIN | Sediment | 0.00002 | Long and Morgan (1990) (ER/L) |
| ENDOSULFAN SULFATE | Sediment | 0.005481 | based on endosulfan |
| ENDRIN KETONE | Sediment | 0.00002 | based on endrin ER/L |
| GAMMA-CHLORDANE | Sediment | 0.0005 | Long and Morgan (1990) (ER/L) |
| HEPTACHLOR | Sediment | 0.0005 | Buchman (1999) Based on chlordane ER/L |
| HEPTACHLOR EPOXIDE | Sediment | 0.0005 | Buchman (1999) Based on chlordane ER/L |
| *SVOC* | | | |
| BIS(2-ETHYLHEXYL)PHTHALATE | Sediment | 890 | Jones et al. (1997) |
| CARBON DISULFIDE | Sediment | 30 | partition: Koc=89; foc=.05; water critical=135 ppm divided by 20 |
| DIBENZOFURAN | Sediment | 0.42 | Jones et al. (1997) |
| DI-N-OCTYL PHTHALATE | Sediment | 11 | Jones et al. (1997) (di-n-butyl phalate as surrogate) |
| *VOC* | | | |
| ACETONE | Sediment | 0.0087 | Jones et al. (1997) |

[1]Aluminum not screened in surface soil because all soil pH measurements were 5.5 or greater, following U.S.EPA (2000)

environmental medium at Site 16 were removed from the list. Also, at the request of U.S. EPA Region 1, several recent references were reviewed to replace some of the older benchmarks from the original list and to provide benchmarks previously listed as "no data." Wherever possible, the soil-screening benchmarks from Oak Ridge National Laboratory were used, either for plants (Efroymson et al. 1997a) or invertebrates or microbial processes (Efroymson et al. 1997b). Dutch values (RIVM 1994, 1997, 2000) were also commonly used, and other sources were employed as necessary (Table 2). If available, marine chronic AWQC were used to screen seep water. If AWQC were not available, the data of Buchman (1999) and Suter (1996) were used. The latter permitted filling some data gaps in the original list, but these are freshwater benchmarks and thus add some uncertainty to the screening process. Seep-sediment-screening benchmarks were primarily Effects Range-Low (ER/L) benchmarks from Long and Morgan (1990) and Long et al. (1995), with other sources used as necessary.

Note that essential nutrients (calcium, iron, magnesium, potassium, and sodium) were not screened in any medium. Also, aluminum was not screened in surface soil because all soil pH measurements were 5.5 or higher, following U.S. EPA (2000) recommendations.

### 1.2.2 COPC-Screening Results: Exposure and Risk Characterization for Lower Trophic Level Terrestrial Organisms, and Aquatic Organisms

#### *Surface Soil*

The results of the surface soil screen are illustrated in Table 3. A total of 51 analytes were detected in surface soil samples. For a relative few of these analytes, HQs exceeded 1.0. These were designated as COPC. The COPC included three metals and eight PAH compounds. Although none of the HQs were very high (none approached 10.0), the conservative nature of the Tier 1 screening requires the presumption of potential risk to terrestrial plants and/or invertebrates. Consequently, these results must be carried into the Scientific Management Decision Process (SMDP) and reviewed by the Risk Assessor and Risk Manager.

Note that no screening benchmarks were available for five organic constituents. Risk to terrestrial plants and invertebrates cannot be assessed in these cases, and this must be considered in the uncertainty assessment of the ERA. (In terms of the soil-based COPC being used to trigger food-web analysis, analytes with no screening benchmarks were considered default COPC, and carried into the food-web evaluation.)

#### *Seep Water*

Water samples from the two ground-water seeps[1] at Site 16 adjacent to Allen Harbor were screened against appropriate benchmarks (Table 4). This is a worst-case assessment, since the benchmarks are designed to protect fish and plankton, and these do not reside in the seeps. No dilution with Allen Harbor water is incorporated into this assessment. Three inorganic and four organic analytes were designated as COPC. Several HQs were relatively high, particularly for barium (HQ=71.4) and manganese (25.4). These HQs were based on

[1] These samples do not include the drainage outfall pipe because its source is offsite, and unrelated to Site 16.

## TABLE 3 SITE 16 SURFACE SOIL COPC SCREEN

| Analyte | Units | Minimum Conc. | Maximum Conc. | Maximum Location | Detection Frequency | Screening Value[1] | HQ | COPC |
|---|---|---|---|---|---|---|---|---|
| ***Inorganics*** | | | | | | | | |
| ALUMINUM | mg/kg | 2570 | 8590 | SB16-28-0-2 | 9/9 | NA[2] | NA[2] | |
| ARSENIC | mg/kg | ND | 4 | SB16-28-0-2 | 7/9 | 10 | 0.4 | |
| BARIUM | mg/kg | 14.8 | 40.6 | SB16-26-0-2 | 9/9 | 500 | 0.1 | |
| BERYLLIUM | mg/kg | 0.33 | 0.64 | SB16-28-0-2 | 9/9 | 10 | 0.1 | |
| CADMIUM | mg/kg | ND | 0.56 | SB16-24-0-2 | 2/9 | 1.6 | 0.4 | |
| CALCIUM | mg/kg | ND | 1200 | SB16-23-0-2 | 8/9 | EN | EN | |
| CHROMIUM | mg/kg | 2.9 | 11.6 | SB16-28-0-2 | 9/9 | 10 | 1.2 | **YES** |
| COBALT | mg/kg | 2 | 7.8 | SB16-28-0-2 | 9/9 | 20 | 0.4 | |
| COPPER | mg/kg | 8.2 | 40.2 | SB16-23-0-2 | 9/9 | 40 | 1.0 | |
| IRON | mg/kg | 5930 | 21200 | SB16-28-0-2 | 9/9 | EN | EN | |
| LEAD | mg/kg | 13.45 | 98.4 | SB16-24-0-2 | 9/9 | 50 | 2.0 | **YES** |
| MAGNESIUM | mg/kg | 540 | 2140 | SB16-28-0-2 | 9/9 | EN | | |
| MANGANESE | mg/kg | 84.4 | 248 | SB16-28-0-2 | 9/9 | 500 | 0.5 | |
| MERCURY | mg/kg | ND | 0.11 | SB16-25-0-2 | 1/9 | 2.2 | 0.1 | |
| NICKEL | mg/kg | ND | 11 | SB16-28-0-2 | 6/9 | 90 | 0.1 | |
| POTASSIUM | mg/kg | ND | 685 | SB16-21-0-2 | 8/9 | EN | EN | |
| SELENIUM | mg/kg | ND | 0.88 | SB16-28-0-2 | 1/9 | 1 | 0.9 | |
| SILVER | mg/kg | ND | 0.32 | SB16-25-0-2 | 1/9 | 50 | 0.0 | |
| SODIUM | mg/kg | ND | 82 | SB16-23-0-2 | 5/9 | EN | EN | |
| THALLIUM | mg/kg | ND | 0.65 | SB16-27-0-2 | 1/9 | 1 | 0.7 | |
| VANADIUM | mg/kg | 4.7 | 16.1 | SB16-28-0-2 | 9/9 | 20 | 0.8 | |
| ZINC | mg/kg | 29.8 | 85.3 | SB16-28-0-2 | 9/9 | 50 | 1.7 | **YES** |
| ***PAH*** | | | | | | | | |
| ACENAPHTHENE | ug/kg | ND | 2400 | 28-SB-01B | 6/29 | 20000 | 0.1 | |
| ACENAPHTHYLENE | ug/kg | ND | 770 | SB16-21-0-2 | 4/29 | 1000 | 0.8 | |
| ANTHRACENE | ug/kg | ND | 4600 | 28-SB-01B | 11/29 | 10000 | 0.5 | |
| BENZO(A)ANTHRACENE | ug/kg | ND | 4450 | SB16-21-0-2 | 18/29 | 1000 | 4.5 | **YES** |
| BENZO(A)PYRENE | ug/kg | ND | 2350 | SB16-21-0-2 | 19/29 | 1000 | 2.4 | **YES** |
| BENZO(B)FLUORANTHENE | ug/kg | ND | 7400 | SB16-21-0-2 | 21/29 | 1000 | 7.4 | **YES** |
| BENZO[G,H,I]PERYLENE | ug/kg | ND | 1050 | SB16-21-0-2 | 17/29 | 1000 | 1.1 | **YES** |

## TABLE 3 SITE 16 SURFACE SOIL COPC SCREEN (C ntinued)

| Analyte | Units | Minimum Conc. | Maximum Conc. | Maximum Location | Detection Frequency | Screening Value | HQ | COPC |
|---|---|---|---|---|---|---|---|---|
| BENZO(K)FLUORANTHENE | ug/kg | ND | 1800 | SB16-21-0-2 | 15/29 | 1000 | 1.8 | **YES** |
| CHRYSENE | ug/kg | ND | 4750 | SB16-21-0-2 | 21/29 | 1000 | 4.8 | **YES** |
| DIBENZO(A,H)ANTHRACENE | ug/kg | ND | 750 | SB16-21-0-2 | 10/29 | 1000 | 0.8 | |
| FLUORANTHENE | ug/kg | ND | 4305 | SB16-21-0-2 | 20/29 | 1000 | 4.3 | **YES** |
| FLUORENE | ug/kg | ND | 592.5 | SB16-21-0-2 | 6/29 | 30000 | 0.0 | |
| INDENO(1,2,3-CD)PYRENE | ug/kg | ND | 2300 | SB16-21-0-2 | 17/29 | 1000 | 2.3 | **YES** |
| NAPHTHALENE | ug/kg | ND | 557 | SB16-21-0-2 | 3/29 | 5000 | 0.1 | |
| PHENANTHRENE | ug/kg | ND | 920 | SB16-28-0-2 | 17/29 | 5000 | 0.2 | |
| PYRENE | ug/kg | ND | 6400 | SB16-21-0-2 | 21/29 | 10000 | 0.6 | |
| ***Pesticide/PCB*** | | | | | | | | |
| 4,4'-DDT | ug/kg | ND | 3.7 | SB16-26-0-2 | 1/8 | 2000 | 0.0 | |
| ALPHA BHC | ug/kg | ND | 2.4 | SB16-28-0-2 | 1/8 | 500 | 0.0 | |
| GAMMA-CHLORDANE | ug/kg | ND | 2.9 | SB16-21-0-2 | 1/9 | 500 | 0.0 | |
| PCB-1260 | ug/kg | ND | 14 | SB16-21-0-2 | 1/9 | 40000 | 0.0 | |
| ***Dioxin/Furan*** | | | | | | | | |
| DIOXIN TOXICITY EQUIVALENT[3] | ppt | 2.60 | 45.21 | SB16-25-0-2 | 8/8 | NSV | NSV | |
| ***SVOC*** | | | | | | | | |
| 2-METHYLNAPHTHALENE | ug/kg | ND | 558 | SB16-21-0-2 | 2/25 | 5000 | 0.1 | |
| BIS(2-ETHYLHEXYL) PHTHALATE | ug/kg | ND | 106 | EBS-28-SB08-0-2 | 2/25 | 30050 | 0.0 | |
| CARBAZOLE | ug/kg | ND | 405 | SB16-21-0-2 | 2/25 | NSV | NSV | |
| DI-N-BUTYL PHTHALATE | ug/kg | ND | 56 | EBS-28-SB05-0-2 | 6/25 | 200000 | 0.0 | |
| ***VOC*** | | | | | | | | |
| 2-BUTANONE | ug/kg | ND | 12 | SB16-27-0-2 | 3/26 | NSV | NSV | |
| ACETONE | ug/kg | ND | 3700 | EBS-28-SB04-0-2 | 14/26 | NSV | NSV | |
| METHYLENE CHLORIDE | ug/kg | ND | 4.5 | EBS-28-SB07-0-2 | 3/26 | NSV | NSV | |
| TOLUENE | ug/kg | ND | 6 | EBS-28-SB15-0-2 | 1/26 | 200000 | 0.0 | |

[1]From Table 2

[2]Aluminum not screened in surface soil because all soil pH measurements were 5.5 or greater, following EPA (2000)

Note: EN=essential nutrient (not screened); NSV=no screening value

[3]Based on World Health Organization (WHO) Toxic Equivalency Factors for mammals.

## TABLE 4 SITE 16 SEEP WATER COPC SCREEN

| Analyte | Minimum Conc. (ug/L) | Maximum Conc. (ug/L) | Maximum Location | Detection Frequency | Screening Value (ug/L) | HQ | COPC |
|---|---|---|---|---|---|---|---|
| ***Metals*** | | | | | | | |
| BARIUM | 1.8 | 271.5 | SEEP16-01 | 2/2 | 3.8 | 71.4 | **YES** |
| CALCIUM | 25700 | 47950 | SEEP16-01 | 2/2 | EN | EN | |
| COBALT | ND | 9 | SEEP16-02 | 1/2 | 3.06 | 2.9 | **YES** |
| IRON | 5100 | 20700 | SEEP16-01 | 2/2 | EN | EN | |
| MAGNESIUM | 4820 | 26200 | SEEP16-02 | 2/2 | EN | EN | |
| MANGANESE | 445 | 2040 | SEEP16-02 | 2/2 | 80.3 | 25.4 | **YES** |
| MERCURY | ND | 0.07 | SEEP16-02 | 1/2 | 0.94 | 0.1 | |
| NICKEL | ND | 2.1 | SEEP16-02 | 1/2 | 8.2 | 0.3 | |
| POTASSIUM | 3575 | 10500 | SEEP16-02 | 2/2 | EN | EN | |
| SODIUM | 13300 | 176000 | SEEP16-02 | 2/2 | EN | EN | |
| ***PAH*** | | | | | | | |
| ACENAPHTHENE | ND | 35.5 | SEEP16-01 | 2/3 | 710 | 0.1 | |
| ACENAPHTHYLENE | ND | 0.2 | SEEP16-01 | 1/3 | 30 | 0.0 | |
| ANTHRACENE | ND | 1.5 | SEEP16-01 | 1/3 | 30 | 0.1 | |
| FLUORANTHENE | ND | 4 | 28-SP-01 | 2/3 | 16 | 0.3 | |
| FLUORENE | ND | 14.5 | SEEP16-01 | 2/3 | 30 | 0.5 | |
| NAPHTHALENE | ND | 4 | SEEP16-01 | 2/3 | 235 | 0.0 | |
| PHENANTHRENE | ND | 7 | 28-SP-01 | 2/3 | 4.6 | 1.5 | **YES** |
| | | | SEEP16-01 | | | | |
| PYRENE | ND | 2 | 28-SP-01 | 2/3 | 30 | 0.1 | |
| ***Pesticide/PCB*** | | | | | | | |
| ALPHA BHC | ND | 0.0325 | SEEP16-01 | 1/3 | 2.44 | 0.0 | |
| DIELDRIN | ND | 0.02 | 28-SP-01 | 1/3 | 0.0019 | 10.5 | **YES** |
| ENDRIN | ND | 0.0039 | 28-SP-01 | 1/3 | 0.0023 | 1.7 | **YES** |
| HEPTACHLOR EPOXIDE | ND | 0.02 | 28-SP-01 | 1/3 | 0.0036 | 5.6 | **YES** |
| ***SVOC*** | | | | | | | |
| 2-METHYLNAPHTHALENE | ND | 0.95 | SEEP16-01 | 1/3 | 30000 | 0.0 | |
| DIBENZOFURAN | 8 | 11.5 | SEEP16-01 | 2/2 | 20.4 | 0.6 | |

## TABLE 4 SITE 16 SEEP WATER COPC SCREEN (Continued)

| Analyte | Minimum Conc. (ug/L) | Maximum Conc. (ug/L) | Maximum Location | Detection Frequency | Screening Value | HQ | COPC |
|---|---|---|---|---|---|---|---|
| ***VOC*** | | | | | | | |
| CIS-1,2-DICHLOROETHENE | ND | 0.7 | SEEP16-02 | 1/2 | 22400 | 0.0 | |
| TOTAL 1,2-DICHLOROETHENE | ND | 0.7 | SEEP16-02 | 1/3 | 22400 | 0.0 | |
| TRICHLOROETHENE | ND | 0.7 | SEEP16-02 | 1/3 | 200 | 0.0 | |
| VINYL CHLORIDE | ND | 0.45 | SEEP16-01 | 1/3 | 87.8 | 0.0 | |

[1]From Tab le 2

Note: EN=essential nutrient (not screened) freshwater benchmarks (Suter 1996), thus increasing uncertainty. Given the exceedance of screening benchmarks for several analytes in the undiluted seep water, a potential risk is inferred to fish and plankton in Allen Harbor. These analytes will be incorporated into SMDP discussions between Risk Assessor and Risk Manager.

***Seep Sediment***

The sediment samples evaluated here were collected in association with the seeps described above. These locations receive drainage from the seeps themselves, but also, due to tidal flushing, rain, or other factors, may be influenced from other areas of Site 16. For these reasons, sediment from below the drainage outfall pipe was included in this assessment. Fifty analytes were detected among these sediment samples, 27 of which produced HQs greater than 1.0 in the screen, and were therefore designated as COPC (Table 5). Several of these COPC had notably high HQs, including acenapthene (56.6), fluorene (30.5), dieldrin (85), and endrin ketone (80). Based on the number of COPC, and the magnitude of HQs for some of them, these sediment locations represent risk to marine benthic fauna. The extent to which these locations—all of which receive drainage from seeps or the outfall pipe—are representative of all shoreline sediment at Site 16 is unknown. These results will be incorporated into the SMDP discussions between Risk Assessor and Risk Manager.

### 1.2.3 Conservative Food-Web Analysis

***Approach***

The Tier 1, Step 2 analysis incorporates a conservative food-web exposure and risk evaluation. Dietary doses of COPC are calculated and compared to TRVs to estimate risk to higher trophic level terrestrial mammals and birds. The ROCs chosen for food-web analysis at Site 16 are the herbivorous Eastern cottontail, omnivorous American robin, and carnivorous red fox. The conservative food web is so named because of key assumptions: (1) COPC concentration in food is assumed to be the same as in dry weight soil samples; (2) ROCs receive 100 percent of their diet from the Site (area use factor [AUF]=1.0); and (3) COPC are 100 percent bioavailable. These conservative assumptions protect against false negative conclusions, i.e., projecting no risk from a COPC when in fact there is risk, per U.S. EPA (1997) guidance.

Dietary exposures for ROCs have been estimated as body-weight-normalized daily doses for comparison to a body-weight-normalized daily dose toxicity reference value (TRV). The daily dose for a given receptor of a given COPC is given by summing the products of feeding rate and food items and multiplying the sum by the total feeding rate and a habitat usage factor (assumed to be 100 percent (1.0) in this conservative food web). Separate doses are presented for soil and food contributions, and these are summed to produce the total dose for each ROC. The model is described below.

$$Dose_{total} = Dose_{food} + Dose_{soil}$$

## TABLE 5 SITE 16 SEDIMENT COPC SCREEN

| Analyte | Units | Minimum Conc. | Maximum Conc. | Maximum Location | Detection Frequency | Screening Value[1] | HQ | COPC |
|---|---|---|---|---|---|---|---|---|
| ***Metals*** | | | | | | | | |
| ALUMINUM | mg/kg | 2370 | 5670 | SED16-02 | 3/3 | 18000 | 0.3 | |
| ANTIMONY | mg/kg | 0.5 | 1.35 | SED16-01 | 3/3 | 2 | 0.7 | |
| ARSENIC | mg/kg | 0.97 | 36.6 | SED16-02 | 3/3 | 8.2 | 4.5 | **YES** |
| BARIUM | mg/kg | 23.5 | 110.1 | SED16-01 | 3/3 | 20 | 5.5 | **YES** |
| BERYLLIUM | mg/kg | 0.32 | 0.905 | SED16-01 | 3/3 | 10 | 0.1 | |
| CADMIUM | mg/kg | ND | 0.19 | SED16-02 | 1/3 | 1.2 | 0.2 | |
| CALCIUM | mg/kg | 1380 | 1815 | SED16-01 | 3/3 | EN | EN | |
| CHROMIUM | mg/kg | 11.7 | 33.5 | OPSED16-01 | 3/3 | 81 | 0.4 | |
| COBALT | mg/kg | 2.4 | 37.9 | SED16-02 | 3/3 | NSV | NSV | |
| COPPER | mg/kg | 13.4 | 127 | SED16-01 | 3/3 | 34 | 3.7 | **YES** |
| IRON | mg/kg | 6400 | 63350 | SED16-01 | 3/3 | EN | EN | |
| LEAD | mg/kg | 11.4 | 154 | OPSED16-01 | 3/3 | 46.7 | 3.3 | **YES** |
| MAGNESIUM | mg/kg | 994 | 2020 | SED16-02 | 3/3 | EN | EN | |
| MANGANESE | mg/kg | 89 | 788 | SED16-02 | 3/3 | 260 | 3.0 | **YES** |
| MERCURY | mg/kg | ND | 0.055 | SED16-01 | 1/3 | 0.15 | 0.4 | |
| NICKEL | mg/kg | 11.5 | 53.8 | SED16-01 | 3/3 | 20.9 | 2.6 | **YES** |
| POTASSIUM | mg/kg | 599 | 916 | SED16-02 | 3/3 | EN | EN | |
| SELENIUM | mg/kg | ND | 1.3 | SED16-01 | 1/3 | 1 | 1.3 | **YES** |
| SODIUM | mg/kg | ND | 239.5 | SED16-01 | 1/3 | EN | EN | |
| VANADIUM | mg/kg | 15.45 | 22.9 | SED16-02 | 3/3 | NSV | NSV | |
| ZINC | mg/kg | 50.5 | 346 | SED16-01 | 3/3 | 150 | 2.3 | **YES** |
| ***PAH*** | | | | | | | | |
| ACENAPHTHENE | ug/kg | ND | 905 | SED16-01 | 1/3 | 16 | 56.6 | **YES** |
| ACENAPHTHYLENE | ug/kg | ND | 110 | OPSED16-01 | 1/3 | 44 | 2.5 | **YES** |
| BENZO(A)ANTHRACENE | ug/kg | 20 | 200 | OPSED16-01 | 3/3 | 261 | 0.8 | |
| BENZO(A)PYRENE | ug/kg | ND | 300 | OPSED16-01 | 1/3 | 430 | 0.7 | |
| BENZO(B)FLUORANTHENE | ug/kg | 41 | 480 | OPSED16-01 | 3/3 | NSV | NSV | |
| BENZO(K)FLUORANTHENE | ug/kg | ND | 340 | OPSED16-01 | 1/3 | 240 | 1.4 | **YES** |
| BENZO[G,H,I]PERYLENE | ug/kg | ND | 380 | OPSED16-01 | 2/3 | 170 | 2.2 | **YES** |
| CHRYSENE | ug/kg | 34 | 450 | OPSED16-01 | 3/3 | 384 | 1.2 | **YES** |
| FLUORANTHENE | ug/kg | 64 | 1800 | SED16-01 | 3/3 | 600 | 3.0 | **YES** |
| FLUORENE | ug/kg | ND | 580 | SED16-01 | 1/3 | 19 | 30.5 | **YES** |

## TABLE 5 SITE 16 SEDIMENT COPC SCREEN (C ntinued)

| Analyte | Units | Minimum Conc. | Maximum Conc. | Maximum Location | Detection Frequency | Screening Value | HQ | COPC |
|---|---|---|---|---|---|---|---|---|
| INDENO(1,2,3-CD)PYRENE | ug/kg | ND | 250 | OPSED16-01 | 1/3 | 200 | 1.3 | **YES** |
| PHENANTHRENE | ug/kg | 44 | 790 | OPSED16-01 | 3/3 | 240 | 3.3 | **YES** |
| PYRENE | ug/kg | 68 | 855 | SED16-01 | 3/3 | 665 | 1.3 | **YES** |
| ***Pesticide/PCB*** | | | | | | | | |
| 4,4'-DDD | ug/kg | ND | 3.45 | SED16-01 | 2/3 | 2 | 1.7 | **YES** |
| 4,4'-DDE | ug/kg | ND | 1.7 | OPSED16-01 | 2/3 | 2.2 | 0.8 | |
| 4,4'-DDT | ug/kg | ND | 1.8 | SED16-02 | 2/3 | 1 | 1.8 | **YES** |
| DELTA BHC | ug/kg | ND | 1.5 | OPSED16-01 | 1/3 | 3 | 0.5 | |
| DIELDRIN | ug/kg | ND | 1.7 | SED16-02 | 1/3 | 0.02 | 85.0 | **YES** |
| ENDOSULFAN SULFATE | ug/kg | ND | 2.1 | SED16-01 | 1/3 | 5.481 | 0.4 | |
| ENDRIN KETONE | ug/kg | 0.64 | 1.6 | OPSED16-01 | 3/3 | 0.02 | 80.0 | **YES** |
| GAMMA-CHLORDANE | ug/kg | ND | 1.7 | OPSED16-01 | 1/3 | 0.5 | 3.4 | **YES** |
| HEPTACHLOR | ug/kg | ND | 0.71 | SED16-02 | 2/3 | 0.5 | 1.4 | **YES** |
| HEPTACHLOR EPOXIDE | ug/kg | ND | 1.2 | OPSED16-01 | 1/3 | 0.5 | 2.4 | **YES** |
| PCB-1260 | ug/kg | ND | 36 | SED16-01 | 1/3 | 22.7 | 1.6 | **YES** |
| ***SVOC*** | | | | | | | | |
| BIS(2-ETHYLHEXYL) PHTHALATE | ug/kg | 320 | 3600 | OPSED16-01 | 3/3 | 890000 | 0.0 | |
| CARBON DISULFIDE | ug/kg | ND | 27.5 | SED16-01 | 2/3 | 30000 | 0.0 | |
| DIBENZOFURAN | ug/kg | ND | 255 | SED16-01 | 1/3 | 420 | 0.6 | |
| DI-N-OCTYLPHTHALATE | ug/kg | ND | 550 | OPSED16-01 | 1/3 | 11000 | 0.1 | |
| ***VOC*** | | | | | | | | |
| ACETONE | ug/kg | 57 | 120 | SED16-02 | 3/3 | 8.7 | 13.8 | **YES** |

[1]From Table 2

Note: EN=essential nutrient (not screened); NSV=no screening value where:

| | | |
|---|---|---|
| $Dose_{total}$ | = | Total daily dose of COPC received by receptor; mg COPC/kg-body wt/day |
| $Dose_{food}$ | = | Daily dose of COPC received by receptor; mg COPC/kg-body wt/day from food items |
| $Dose_{soil}$ | = | Daily dose of COPC received by receptor; mg COPC/kg-body wt/day from incidentally ingested soil |

The total dose from food is given by:

$$Dose_{food} = F_f \; x \; U \; x \; C_f$$

where:

| | | |
|---|---|---|
| $F_f$ | = | Total daily feeding rate in kg food/kg-body weight of ROC/day (wet basis) |
| U | = | Habitat usage factor (fraction of habitat range represented by site) for receptor; assumed to be 1.0 for this food web |
| $C_f$ | = | Concentration of COPC in food; assumed to be the same concentration as soil (mg chemical/kg food) |

The total dose from incidental soil is given by:

$$Dose_{soil} = F_s \; x \; U \; x \; C_s$$

where:

| | | |
|---|---|---|
| $F_s$ | = | Total daily incidental soil feeding rate in kg soil/kg-body weight of ROC/day (wet basis) |
| U | = | Habitat usage factor (fraction of habitat range represented by site) for receptor; assumed to be 1.0 for this food web |
| $C_s$ | = | Concentration of COPC in soil; mg chemical/kg soil (dry basis) |

Lastly, the total daily incidental soil feeding rate is given by:

$$F_s = F_f \; x \; F_{xsoil}$$

where:

| | | |
|---|---|---|
| $F_s$ | = | Total daily incidental soil feeding rate in kg soil/day (wet basis) |
| $F_f$ | = | Total daily feeding rate in kg food/day (wet basis) |
| $F_{xsoil}$ | = | Fraction incidental soil ingestion as a proportion of food ingestion rate |

Information necessary for calculation includes organism body weight (BW), food ingestion rate ($F_f$), fraction incidental soil ingestion as a proportion of food ingestion rate ($F_{xsoil}$) and analyte concentrations of ingested materials. As discussed earlier, vegetation and animal food items were represented by the same concentration as found in soil (dry weight). Information specifically relevant to the ecology of the ROCs (i.e., body weights, food ingestion rates, and incidental soil ingestion rates) (Table 6) was obtained from published sources. The primary source used for these exposure parameters was the Exposure Factors Handbook (U.S.EPA 1993).

Risk characterization for the food-web analysis is calculated similarly to the media screening:

HQ = dietary dose of COPC/Toxicity Reference Value (TRV)

If the dietary dose is lower than the TRV, the HQ is less than 1.0 and no risk is inferred. If the dietary dose is higher than the TRV, the HQ is greater than 1.0, and some potential level of risk is inferred. The TRVs used are NOAEL-based dietary doses obtained from the U.S. Navy Engineering Field Activity Northeast (EFANE) soil-screening database, which in turn were based largely on toxicological data from Oak Ridge National Laboratory (Sample et al. 1996). The TRVs used are listed in Table 7.

**Example Food-Web Exposure and Risk Calculation**

The example HQ calculation provided below estimates the potential for risk to the red fox exposed to soil containing a concentration of lead.

Assume the maximum concentration of lead reported in surface soil (dry weight basis) was determined to be 40.9 mg/kg. The only food item for the red fox will be soil.

The following equation provides the dose to the receptor from food ingestion:

$$Dose_{food} = \frac{F_f \, x \, U \, x \, C_f}{BW}$$

= (0.320 kg/day x 1.0 x 40.9 mg/kg)/5.0 kg

= 2.6176 mg/kg-bw/day

where:

| | | |
|---|---|---|
| $F_f$ | = | Total daily feeding rate in kg food/day (wet basis) (Table 6) |
| U | = | Habitat usage factor (fraction of habitat range represented by site) for receptor; assumed to be 1.0 for this food web |
| $C_f$ | = | Concentration of COPC in soil |
| BW | = | Body weight of ROC (kg) (Table 6) |

The dose from incidental soil ingestion is calculated using:

## TABLE 6 FOOD-WEB EXPOSURE FACTORS FOR ECOLOGICAL RECEPTORS OF CONCERN

| Exposure Factor | American Robin | Red Fox | Eastern Cottontail |
|---|---|---|---|
| Body Weight (kg) | 0.0810200 (U.S. EPA 1993) | 5.0 (U.S. EPA 1993) | 1.134 (Sample and Suter 1994) |
| Food Ingestion Rate (kg/day) | 0.0976300 (U.S. EPA 1993) | 0.320 (U.S. EPA 1993) | 0.237 (Sample and Suter 1994) |
| Soil Ingestion Rate (kg/day) | 0.0292890 (Based on 10% of food ingestion rate, U.S. EPA 1993) | 0.0090 (Based on 3% of food ingestion rate, U.S. EPA 1993) | 0.015 (Based on 6.3% of food ingestion rate, Sample and Suter 1994) |
| Habitat Ratio (relative to site size of 4.5 Ha) | 1.0 (Based on habitat range of 0.4 Ha, U.S. EPA 1993) | 1.0 for conservative food web and 0.006 for refined food web (Based on a habitat range of 750 Ha, U.S. EPA 1993) | 1.0 (Based on habitat range of 4.0 Ha, U.S. EPA 1993) |

## TABLE 7 LIST OF TOXICITY REFERENCE VALUES (TRVs) FOR USE IN FOOD-WEB MODELING

| | Eastern cottontail mg/kg-bw/day | Red fox mg/kg-bw/day | American robin mg/kg-bw/day |
|---|---|---|---|
| **Inorganics** | | | |
| Chromium | 1445.0 | 1445.0 | 1.0 |
| Lead | 4.22 | 4.22 | 3.85 |
| Zinc | 84.5 | 84.5 | 14.5 |
| **PAH** | | | |
| Benzo(a)pyrene* | 0.29 | 0.29 | -- |
| **SVOC** | | | |
| 2-Butanone | 935 | 935 | -- |
| Carbazole | -- | -- | -- |
| **Dioxin/Furan** | | | |
| 2,3,7,8-TCDD | 0.0000005 | 0.0000005 | 0.000014 |
| **VOC** | | | |
| Acetone | 5.3 | 5.3 | -- |
| Methylene chloride | 3.1 | 3.1 | -- |

Dashed line indicates no TRV available

Notes: TRVs accessed from U.S. Navy, Naval Facilities Engineering Command, Northern Division Benchmark Screening Values Database (based on Sample et al. [1996])

Eastern cottontail and red fox TRVs are identical because both are classified as "medium mammals" in the Navy Benchmark Screening Values Database

*TRV available only for benzo(a)pyrene; this value used for all PAH COPC .

$$Dose_{soil} = \frac{F_s \, x \, U \, x \, C_s}{BW}$$

= (0.0090 kg/day x 1.0 x 40.9 mg/kg)/5.0 kg

= 0.0736 mg/kg-bw/day

where:

| | | |
|---|---|---|
| $F_s$ | = | Total daily soil feeding rate in kg soil/day (wet basis) (Table 6) |
| U | = | Habitat usage factor (fraction of habitat range represented by site) for receptor; assumed to be 1.0 for this food web |
| $C_s$ | = | Concentration of COPC in soil; mg chemical/kg soil (dry basis) |
| BW | = | Body weight of ROC (kg) (Table 6) |

The final dose is calculated as follows:

$Dose_{total} = Dose_{soil} + Dose_{food}$

$Dose_{total} = 0.0736 + 2.6176$

$Dose_{total} = 2.69$ mg/kg-bw/day

The hazard quotient is calculated from the dose and the NOAEL-based TRV (Table 7) as follows:

$$HQ = \frac{DOSE}{TRV_{NOAEL}}$$

$$HQ = \frac{2.69 \, mg / kg / day}{4.22 \, mg / kg / day}$$

$$HQ = 0.6377$$

### *Site 16 Conservative Food Web Results*

The results of the conservative food-web analysis are displayed in Tables 8, 9, and 10 for the Eastern cottontail, red fox, and American robin, respectively. In each case, several HQs exceeded 1.0, and thus reflect potential risk. The cottontail had nine HQs greater than 1.0, but most were relatively low. Only the Dioxin Toxicity Equivalent HQ exceeded 10. The fox reflected fewer HQs greater than 1.0, most relatively low. Only the Dioxin Toxicity Equivalent HQ exceeded 2.0. For the robin, only four HQs could be calculated, because of a lack of avian TRV data for PAH and other organic compounds. Robin HQs for metals were higher than those of the other ROCs (Table 10). This is

## TABLE 8 CONSERVATIVE FOOD-WEB RESULTS FOR THE EASTERN COTTONTAIL
## NCBC DAVISVILLE SITE 16

| Ecological Contaminant of Concern | Soil Concentration (mg/kg) | Food Concentration (mg/kg) | Dose (mg/kg/day) | TRV (mg/kg/day) | HQ | HQ>1? |
|---|---|---|---|---|---|---|
| Chromium | 11.6 | 11.6 | 2.578 | 1445 | 0.0 | |
| Lead | 98.4 | 98.4 | 21.867 | 4.22 | 5.2 | **YES** |
| Zinc | 85.3 | 85.3 | 18.956 | 84.5 | 0.2 | |
| Benzo(a)anthracene | 4.45 | 4.45 | 0.989 | 0.29 | 3.4 | **YES** |
| Benzo(a)pyrene | 2.35 | 2.35 | 0.522 | 0.29 | 1.8 | **YES** |
| Benzo(b)fluoranthene | 7.4 | 7.4 | 1.644 | 0.29 | 5.7 | **YES** |
| Benzo[g,h,i]perylene | 1.05 | 1.05 | 0.233 | 0.29 | 0.8 | |
| Benzo(k)fluoranthene | 1.8 | 1.8 | 0.400 | 0.29 | 1.4 | **YES** |
| Chrysene | 4.75 | 4.75 | 1.056 | 0.29 | 3.6 | **YES** |
| Fluoranthene | 4.305 | 4.035 | 0.900 | 0.29 | 3.1 | **YES** |
| Indeno(1,2,3-cd)pyrene | 2.3 | 2.3 | 0.511 | 0.29 | 1.8 | **YES** |
| Dioxin Toxicity Equivalent | 0.00004521 | 0.00004521 | 0.000 | 0.0000005 | 20.1 | **YES** |
| Carbazole | 0.405 | 0.405 | 0.090 | No TRV | No TRV | |
| 2-Butanone | 0.012 | 0.012 | 0.003 | 1301 | 0.0 | |
| Acetone | 3.7 | 3.7 | 0.822 | 7.3 | 0.1 | |
| Methylene chloride | 0.0045 | 0.0045 | 0.001 | 4.3 | 0.0 | |

## TABLE 9 CONSERVATIVE FOOD-WEB RESULTS FOR THE RED FOX, NCBC DAVISVILLE SITE 16

| Ecological Contaminant of Concern | Soil Concentration (mg/kg) | Food Concentration (mg/kg) | Dose (mg/kg/day) | TRV (mg/kg/day) | HQ | HQ>1? |
|---|---|---|---|---|---|---|
| Chromium | 11.6 | 11.6 | 0.763 | 1445 | 0.0 | |
| Lead | 98.4 | 98.4 | 6.475 | 4.22 | 1.5 | **YES** |
| Zinc | 85.3 | 85.3 | 5.613 | 84.5 | 0.1 | |
| Benzo(a)anthracene | 4.45 | 4.45 | 0.293 | 0.29 | 1.0 | **YES** |
| Benzo(a)pyrene | 2.35 | 2.35 | 0.155 | 0.29 | 0.5 | |
| Benzo(b)fluoranthene | 7.4 | 7.4 | 0.487 | 0.29 | 1.7 | **YES** |
| Benzo[g,h,i]perylene | 1.05 | 1.05 | 0.069 | 0.29 | 0.2 | |
| Benzo(k)fluoranthene | 1.8 | 1.8 | 0.118 | 0.29 | 0.4 | |
| Chrysene | 4.75 | 4.75 | 0.313 | 0.29 | 1.1 | **YES** |
| Fluoranthene | 4.305 | 4.035 | 0.266 | 0.29 | 0.9 | |
| Indeno(1,2,3-cd)pyrene | 2.3 | 2.3 | 0.151 | 0.29 | 0.5 | |
| Dioxin Toxicity Equivalent | 0.00004521 | 0.00004521 | 0.000 | 0.0000005 | 5.9 | **YES** |
| Carbazole | 0.405 | 0.405 | 0.027 | No TRV | No TRV | |
| 2-Butanone | 0.012 | 0.012 | 0.001 | 935 | 0.0 | |
| Acetone | 3.7 | 3.7 | 0.243 | 5.3 | 0.0 | |
| Methylene chloride | 0.0045 | 0.0045 | 0.000 | 3.1 | 0.0 | |

## TABLE 10 CONSERVATIVE FOOD-WEB RESULTS FOR THE AMERICAN ROBIN NCBC DAVISVILLE SITE 16

| Ecological Contaminant of Concern | Soil Concentration (mg/kg) | Food Concentration (mg/kg) | Dose (mg/kg/day) | TRV (mg/kg/day) | HQ | HQ>1? |
|---|---|---|---|---|---|---|
| Chromium | 11.6 | 11.6 | 15.376 | 1 | 15.4 | **YES** |
| Lead | 98.4 | 98.4 | 130.430 | 3.85 | 33.9 | **YES** |
| Zinc | 85.3 | 85.3 | 113.066 | 14.5 | 7.8 | **YES** |
| Benzo(a)anthracene | 4.45 | 4.45 | 5.899 | NoTRV | NoTRV | |
| Benzo(a)pyrene | 2.35 | 2.35 | 3.115 | NoTRV | NoTRV | |
| Benzo(b)fluoranthene | 7.4 | 7.4 | 9.809 | NoTRV | NoTRV | |
| Benzo[g,h,i]perylene | 1.05 | 1.05 | 1.392 | NoTRV | NoTRV | |
| Benzo(k)fluoranthene | 1.8 | 1.8 | 2.386 | NoTRV | NoTRV | |
| Chrysene | 4.75 | 4.75 | 6.296 | NoTRV | NoTRV | |
| Fluoranthene | 4.305 | 4.035 | 5.381 | NoTRV | NoTRV | |
| Indeno(1,2,3-cd)pyrene | 2.3 | 2.3 | 3.049 | NoTRV | NoTRV | |
| Dioxin Toxicity Equivalent | 0.00007554 | 0.00007554 | 0.000 | 0.000014 | 7.2 | **YES** |
| Carbazole | 0.405 | 0.405 | 0.537 | No TRV | No TRV | |
| 2-Butanone | 0.012 | 0.012 | 0.016 | No TRV | No TRV | |
| Acetone | 3.7 | 3.7 | 4.904 | No TRV | No TRV | |
| Methylene chloride | 0.0045 | 0.0045 | 0.006 | No TRV | No TRV | |

likely due to the high food ingestion rate of the robin (greater than 100 percent of its body weight per day) and relatively high incidental soil ingestion rate (10 percent of food ingestion rate).

In many screening-level ERAs, the conservative food-web results are the sole estimates of risk to higher trophic level ROCs. These are the results that are carried into the SMDP for discussion between Risk Assessor and Risk Manager. However, U.S. Navy policy for ecological risk assessment (U.S. Navy 1999) affords the opportunity to refine the food-web risk characterization using more realistic assumptions. This is termed Tier 2 Step 3a in Navy guidance (Figure 1), and is implemented in the following section for Site 16.

### 1.2.4 Step 3a Refined Food-Web Analysis

The refined food web is based on the same model described in the last section, but differs in three important aspects:

1. Realistic Area Use Factors (AUF) are employed to provide a more realistic estimate of the amount of time an ROC may spend foraging on Site 16. In this assessment, only the AUF for the red fox differs from the conservative model. The fox's home range is considerably larger than Site 16, whereas the home ranges of the cottontail and robin are smaller than Site 16.

2. COPC concentrations in food items and incidental soil were converted to a wet weight basis to reflect conditions in the natural environment, as recommended by U.S. EPA (1993).

3. Where available, Bioaccumulation Factors (BAFs) were employed to estimate COPC concentrations in food items (Table 11). Many chemicals are found in much lower concentrations in food items relative to soil; use of BAFs provides a more realistic exposure (dose) calculation. When BAFs were not available, the default value of 1.0 was used.

The results of the refined food-web analysis are displayed in Tables 12, 13, and 14 for the Eastern cottontail, red fox, and American robin, respectively. The impact of the Step 3a refinements is immediately obvious—there has been a substantial reduction in the magnitude of HQs and the number exceeding 1.0. No suggestion of risk remains for the cottontail or red fox. The refinements, and in particularly the AUF of 0.006 for the fox (Table 6) have reduced HQs to very low levels. Robin HQs for chromium, lead, zinc, and Dioxin Toxicity Equivalent remain greater than 1.0 in the refined assessment, but have been reduced by about 50 to 80 percent, depending on analyte.

Overall, the perception of risk to terrestrial birds and mammals reflected in the conservative food web has been reduced to a *de minimus* level by the Step 3a refinement. It is anticipated that this will be discussed between Risk Assessor and Risk Manager in the context of the SMDP.

## TABLE 11 BIOACCUMULATION FACTORS (BAFs) USED IN REFINED FOOD-WEB MODEL

| Analyte | Invertebrate | | | Plant | | | Mammal | | |
|---|---|---|---|---|---|---|---|---|---|
| | BAF | Type | Source | BAF | Type | Source | BAF | Type | Source |
| Chromium | 0.50592 | 90th percentile UF | (1) | 1 | conservative | (2) | 0.0373 | general regression | (5) |
| Lead | 0.053 | simple regression | (1) | 0.0085 | simple regression | (3) | 0.0157 | general regression | (5) |
| Zinc | 0.69 | simple regression | (1) | 0.16 | simple regression | (3) | 0.456 | general regression | (5) |
| Benz(a)anthracene | 1.0 | conservative | (2) | 0.017 | geometric mean regression | (4) | 1 | conservative | (2) |
| Benzo(a)pyrene | 1.0 | conservative | (2) | 0.011 | geometric mean regression | (4) | 1 | conservative | (2) |
| Benzo(b)fluoranthene | 1.0 | conservative | (2) | 0.009 | geometric mean regression | (4) | 1 | conservative | (2) |
| Benzo(g,h,i)perylene | 1.0 | conservative | (2) | 0.005 | geometric mean regression | (4) | 1 | conservative | (2) |
| Benzo(k)fluoranthene | 1.0 | conservative | (2) | 0.0008 | geometric mean regression | (4) | 1 | conservative | (2) |
| Chrysene | 1.0 | conservative | (2) | 0.017 | geometric mean regression | (4) | 1 | conservative | (2) |
| Fluoranthene | 1.0 | conservative | (2) | 0.042 | geometric mean regression | (4) | 1 | conservative | (2) |
| Indeno(1,2,3-cd)pyrene | 1.0 | conservative | (2) | 0.005 | geometric mean regression | (4) | 1 | conservative | (2) |
| Dioxin Toxicity Equivalent | 1.0 | conservative | (2) | 0.009 | geometric mean regression | (4) | 1 | conservative | (2) |
| Carbazole | 1.0 | conservative | (2) | 1 | conservative | (2) | 1 | conservative | (2) |
| 2-Butanone | 1.0 | conservative | (2) | 1 | geometric mean regression | (2) | 1 | conservative | (2) |
| Acetone | 1.0 | conservative | (2) | 1 | geometric mean regression | (2) | 1 | conservative | (2) |
| Methylene chloride | 1.0 | conservative | (2) | 1 | conservative | (2) | 1 | conservative | (2) |

Note: UF=uptake factor. BAFs are dry soil/wet tissue basis.

(1)Sample et al. 1998a

(2)default

(3)Bechtel Jacobs 1998

(4)Travis and Arms 1988

(5)Sampel et al. 1998b

**TABLE 12 STEP 3a REFINED FOOD-WEB RESULTS FOR THE EASTERN COTTONTAIL, NCBC DAVISVILLE SITE 16**

| Ecological Contaminant of Concern | Soil Concentration (mg/kg) | Vegetation Concentration (mg/kg) | Dose (mg/kg/day) | TRV (mg/kg/day) | HQ | HQ>1? |
|---|---|---|---|---|---|---|
| Chromium | 9.164 | 2.7840 | 0.7031 | 1445 | 0.00 | |
| Lead | 77.736 | 0.8347 | 1.2027 | 4.22 | 0.29 | |
| Zinc | 67.387 | 13.6742 | 3.7492 | 84.5 | 0.04 | |
| Benz(a)anthracene | 3.516 | 0.0224 | 0.0512 | 0.29 | 0.18 | |
| Benzo(a)pyrene | 1.857 | 0.0079 | 0.0262 | 0.29 | 0.09 | |
| Benzo(b)fluoranthene | 5.846 | 0.0195 | 0.0814 | 0.29 | 0.28 | |
| Benzo(g,h,i)perylene | 0.830 | 0.0015 | 0.0113 | 0.29 | 0.04 | |
| Benzo(k)fluoranthene | 1.422 | 0.0004 | 0.0189 | 0.29 | 0.07 | |
| Chrysene | 3.753 | 0.0239 | 0.0546 | 0.29 | 0.19 | |
| Fluoranthene | 3.401 | 0.0548 | 0.0564 | 0.29 | 0.19 | |
| Indeno(1,2,3-cd)pyrene | 1.817 | 0.0033 | 0.0247 | 0.29 | 0.09 | |
| Dioxin Toxicity Equivalent | 3.572E-05 | 1.1935E-07 | 4.9738E-07 | 0.0000005 | 0.99 | |
| Carbazole | 0.320 | 0.0972 | 0.0245 | No TRV | No TRV | |
| 2-Butanone | 0.009 | 0.0029 | 0.0007 | 935 | 0.00 | |
| Acetone | 2.923 | 0.8880 | 0.2243 | 5.3 | 0.04 | |
| Methylene chloride | 0.004 | 0.0011 | 0.0003 | 3.1 | 0.00 | |

TABLE 13 STEP 3a REFINED FOOD-WEB RESULTS FOR THE RED FOX, NCBC DAVISVILLE SITE 16

| Ecological Contaminant of Concern | Soil Concentration (mg/kg) | Vegetation Concentration (mg/kg) | Mammal Concentration (mg/kg) | Dose (mg/kg/day) | TRV (mg/kg/day) | HQ | HQ>1? |
|---|---|---|---|---|---|---|---|
| Chromium | 9.1640 | 2.7840 | 0.4324 | 0.0004 | 1445 | 0.00 | |
| Lead | 77.7360 | 0.8347 | 1.5439 | 0.0014 | 4.22 | 0.00 | |
| Zinc | 67.3870 | 13.6742 | 38.8611 | 0.0147 | 84.5 | 0.00 | |
| Benz(a)anthracene | 3.5155 | 0.0224 | 1.4240 | 0.0005 | 0.29 | 0.00 | |
| Benzo(a)pyrene | 1.8565 | 0.0079 | 0.7520 | 0.0003 | 0.29 | 0.00 | |
| Benzo(b)fluoranthene | 5.8460 | 0.0195 | 2.3680 | 0.0009 | 0.29 | 0.00 | |
| Benzo(g,h,i)perylene | 0.8295 | 0.0015 | 0.3360 | 0.0001 | 0.29 | 0.00 | |
| Benzo(k)fluoranthene | 1.4220 | 0.0004 | 0.5760 | 0.0002 | 0.29 | 0.00 | |
| Chrysene | 3.7525 | 0.0239 | 1.5200 | 0.0006 | 0.29 | 0.00 | |
| Fluoranthene | 3.4010 | 0.0548 | 1.3776 | 0.0005 | 0.29 | 0.00 | |
| Indeno(1,2,3-cd)pyrene | 1.8170 | 0.0033 | 0.7360 | 0.0003 | 0.29 | 0.00 | |
| Dioxin Toxicity Equivalent | 3.5716E-05 | 1.1935E-07 | 1.4467E-05 | 5.3902E-09 | 0.0000005 | 0.01 | |
| Carbazole | 0.3200 | 0.0972 | 0.1296 | 0.0001 | No TRV | NA | |
| 2-Butanone | 0.0095 | 0.0029 | 0.0038 | 1.5401E-06 | 935 | 0.00 | |
| Acetone | 2.9230 | 0.8880 | 1.1840 | 0.0005 | 5.3 | 0.00 | |
| Methylene chloride | 0.0036 | 0.0011 | 0.0014 | 5.7753E-07 | 3.1 | 0.00 | |

**TABLE 14 STEP 3a REFINED FOOD-WEB RESULTS FOR THE AMERICAN ROBIN, NCBC DAVISVILLE SITE 16**

| Ecological Contaminant of Concern | Soil Concentration (mg/kg) | Vegetation Concentration (mg/kg) | Invertebrate Concentration (mg/kg) | Dose (mg/kg/day) | TRV (mg/kg/day) | HQ | HQ>1? |
|---|---|---|---|---|---|---|---|
| Chromium | 9.164 | 2.7840 | 0.939 | 2.992 | 1 | 2.99 | YES |
| Lead | 77.736 | 0.8347 | 5.221 | 13.862 | 3.85 | 3.60 | YES |
| Zinc | 67.387 | 13.6742 | 58.837 | 60.516 | 14.5 | 4.17 | YES |
| Benz(a)anthracene | 3.516 | 0.0224 | 0.712 | 0.999 | No TRV | NA | |
| Benzo(a)pyrene | 1.857 | 0.0079 | 0.376 | 0.526 | No TRV | NA | |
| Benzo(b)fluoranthene | 5.846 | 0.0195 | 1.184 | 1.654 | No TRV | NA | |
| Benzo(g,h,i)perylene | 0.830 | 0.0015 | 0.168 | 0.234 | No TRV | NA | |
| Benzo(k)fluoranthene | 1.422 | 0.0004 | 0.288 | 0.401 | No TRV | NA | |
| Chrysene | 3.753 | 0.0239 | 0.760 | 1.066 | No TRV | NA | |
| Fluoranthene | 3.401 | 0.0548 | 0.689 | 0.980 | No TRV | NA | |
| Indeno(1,2,3-cd)pyrene | 1.817 | 0.0033 | 0.368 | 0.513 | No TRV | NA | |
| Dioxin Toxicity Equivalent | 5.967E-05 | 1.5754E-07 | 1.209E-05 | 1.687E-05 | 0.000014 | 1.20 | YES |
| Carbazole | 0.320 | 0.0972 | 0.065 | 0.130 | No TRV | NA | |
| 2-Butanone | 0.009 | 0.0029 | 0.002 | 0.004 | No TRV | NA | |
| Acetone | 2.923 | 0.8880 | 0.592 | 1.187 | No TRV | NA | |
| Methylene chloride | 0.004 | 0.0011 | 0.001 | 0.001 | No TRV | NA | |

### 1.2.5 Uncertainty

Ecological risk characterization includes analysis of uncertainty (U.S.EPA 1997). Uncertainty is distinguished from variability, and arises from lack of knowledge about factors associated with the study. In a screening-level assessment such as this one, uncertainty typically stems from two study facets: the sampling plan and the toxicological data. Sources of uncertainty can include the process of selecting COPCs, assumptions made in establishing the Conceptual Site Model, adequacy of ecological characterization of the Site, estimates of toxicity to receptors, and selection of model parameters. There are a number of factors that contribute to uncertainty in the ecological risk characterization for Site 16, as described below.

- Environmental media are typically sampled in a non-random fashion. That is, sampling points are chosen to best characterize known or suspected areas of contamination. Peripheral and nearby areas are undersampled, if at all, and thus the average exposure of ecological receptors is biased high. This is particularly true of the use of seep water and sediment samples to represent broader open water and sediment environments in Allen Harbor.

- A Tier 1 ERA uses the maximum measured concentration to estimate risks consistent with guidance, which represents a high bias in exposure to ROCs.

- Toxicological data used in the risk characterization represent significant uncertainty. Because there may be no known data on the effects of chemical constituents on specific ROCs, some chemicals are not screened at all, or toxicological data for surrogate species are sometimes used, and this adds uncertainty.

- Food-item concentrations were overestimated in the conservative food web. The extremely conservative assumption was made that all food (vegetation, soil invertebrates, etc.) was at the same concentration as the dry-weight soil maximum, and 100 percent bioavailable. The resulting high uncertainty was greatly reduced in the refined food web. However, some uncertainty remains due to the use of literature-based BAFs or conservative default values in lieu of onsite tissue concentrations.

- The toxicological data that underpin the screening values are inherently uncertain because laboratory data are extrapolated to specific field sites such as Site 16. This uncertainty is to some extent controlled by choosing the lowest available screening values, consistent with USEPA (1997) guidance to "be consistently conservative in selecting literature values..." This also contributes to overestimation of risk.

Although the direction of bias of some uncertainties is unknown, the overriding influence of the non-random media sampling and assumptions of 100 percent bioavailability assures that risks are overestimated for lower trophic level terrestrial organisms, aquatic organisms, and terrestrial birds and mammals in the conservative food web. Uncertainty surrounding risks to terrestrial birds and mammals was greatly reduced by the refined food web. Some uncertainty remains, however, associated with literature-based BAFs and toxicological data.

## 1.3 SUMMARY OF SITE 16 ECOLOGICAL RISK ASSESSMENT

The results of the various screening assessments and food-web evaluations discussed above are compiled and summarized in Table 15. This was done to create a context where potential risk from all environmental media to all receptors can be evaluated at the same time.

Exposure to contaminants in surface soil reflects some potential risk to terrestrial plants and invertebrates and—based on the conservative food web—to terrestrial mammals and birds. There are a number of HQs>1 for terrestrial plants and invertebrates; none is very high, suggesting a low potential for risk to these receptors. Soil-based risks to terrestrial mammals and birds, potentially significant based on the conservative food web, virtually disappeared with the application of the refined food web.

The screening assessments in the aquatic environment indicated the potential for risk to fish and plankton in Allen Harbor from seep water and to benthos from seep sediment. Relatively few HQs in seep water exceeded 1.0, but barium and manganese were relatively high. There is a substantial high-bias uncertainty in this assessment because the target ROCs, fish and plankton in Allen Harbor, would not encounter such concentrations once the seep water entered and was diluted within Allen Harbor. The seep sediment results represent potential risk to marine invertebrates in the benthic community, particularly from manganese and several PAH and pesticide compounds. It has not been determined whether the seep sediment areas represent "hot spots" or whether the data reflect general sediment conditions throughout the Site 16 shoreline area.

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## TABLE 15 SUMMARY OF SITE 16 RISK CALCULATIONS (HQs>1) IN ALL MEDIA FOR ALL ROC

| | | | | Conservative Food Web | | | Refined Food Web | | |
|---|---|---|---|---|---|---|---|---|---|
| | Surface Soil | Seep Water | Seep Sediment | Surface Soil | Surface Soil | Surface Soil | Surface Soil | Surface Soil | Surface Soil |
| **Analyte** | Terrestrial Plants/ Invertebrates | Marine Fish/ Plankton | Marine Benthos | Eastern Cottontail | Red Fox | American Robin | Eastern Cottontail | Red Fox | American Robin |
| ***Inorganics*** | | | | | | | | | |
| ARSENIC | | | 4.5 | | | | | | |
| BARIUM | | 71.4 | 5.5 | | | | | | |
| CHROMIUM | 1.2 | | | | | 15.4 | | | 3.0 |
| COBALT | | 2.9 | | | | | | | |
| COPPER | | | 3.7 | | | | | | |
| LEAD | 2.0 | | 3.3 | 5.2 | 1.5 | 33.9 | | | 3.6 |
| MANGANESE | | 25.4 | 3.0 | | | | | | |
| NICKEL | | | 2.6 | | | | | | |
| SELENIUM | | | 1.3 | | | | | | |
| ZINC | 1.7 | | 2.3 | | | 7.8 | | | 4.2 |
| ***PAH*** | | | | | | | | | |
| ACENAPHTHENE | | | 56.6 | | | | | | |
| ACENAPHTHYLENE | | | 2.5 | | | | | | |
| BENZO(A)ANTHRACENE | 4.5 | | | 3.4 | 1.0 | | | | |
| BENZO(A)PYRENE | 2.4 | | | 1.8 | | | | | |
| BENZO(B)FLUORANTHENE | 7.4 | | | 5.7 | 1.7 | | | | |
| BENZO[G,H,I]PERYLENE | 1.1 | | 2.2 | | | | | | |
| BENZO(K)FLUORANTHENE | 1.8 | | 1.4 | 1.4 | | | | | |
| CHRYSENE | 4.8 | | 1.2 | 3.6 | 1.1 | | | | |
| FLUORANTHENE | 4.3 | | 3.0 | 3.1 | | | | | |
| FLUORENE | | | 30.5 | | | | | | |
| INDENO(1,2,3-CD)PYRENE | 2.3 | | 1.3 | 1.8 | | | | | |
| PHENANTHRENE | | 1.5 | 3.3 | | | | | | |
| PYRENE | | | 1.3 | | | | | | |
| ***Pesticide/PCB*** | | | | | | | | | |
| 4,4'-DDD | | | 1.7 | | | | | | |
| 4,4'-DDT | | | 1.8 | | | | | | |
| DIELDRIN | | 10.5 | 85.0 | | | | | | |
| ENDRIN | | 1.7 | | | | | | | |

## TABLE 15 SUMMARY OF SITE 16 RISK CALCULATIONS (HQs>1) IN ALL MEDIA FOR ALL ROC (C ntinued)

| | | | | Conservative Food Web | | | Refined Food Web | | |
|---|---|---|---|---|---|---|---|---|---|
| **Analyte** | Surface Soil Terrestrial Plants/ Invertebrates | Seep Water Marine Fish/ Plankton | Seep Sediment Marine Benthos | Surface Soil Eastern Cottontail | Surface Soil Red Fox | Surface Soil American Robin | Surface Soil Eastern Cottontail | Surface Soil Red Fox | Surface Soil American Robin |
| ENDRIN KETONE | | | 80.0 | | | | | | |
| GAMMA-CHLORDANE | | | 3.4 | | | | | | |
| HEPTACHLOR | | | 1.4 | | | | | | |
| HEPTACHLOR EPOXIDE | | 5.6 | 2.4 | | | | | | |
| PCB-1260 | | | 1.6 | | | | | | |
| ***Dioxin/Furan*** | | | | | | | | | |
| DIOXIN TOXICITY EQUIVALENT | | | | 20.1 | 5.9 | 7.2 | | | 1.2 |
| ***VOC*** | | | | | | | | | |
| ACETONE | | | 13.8 | | | | | | |

*Naval Construction Battalion Center North Kingston, RI.* Prepared for Northern Division Naval Facilities Engineering Command, Lester, PA. Prepared by EA Engineering, Science, and Technology, Inc., Bedford, MA.

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